Original Research Article:

Association Between Maternal Anthropometry and Birth Outcome

Patra S*, Sarangi GD**

*Post Graduate Student. **Prof. and HOD Department of Pediatrics, Hitech Medical College & Hospital, Bhubaneswar, Odisha. Corresponding author: Dr. Gadadhar Sarangi, Prof. and HOD Department of Pediatrics, Hitech Medical College & Hospital,Bhubaneswar, Odisha.Email ID – drgadadhars@gmail.com Received:February 23 ,2017. Reviewed: March,27,2016. Accepted: April,25,2017.

Abstract

Maternal body dimensions are first determinants of neonate biometrics; predominantly their birth weight and length, which are closely related to perinatal morbidity and mortality(1), it was known that mother's nutritional status is also known to be a key indicator of infant's body dimensions and its early growth features. Birth weight and length are clearly related to mother's nutritional (2) and anthropometric factors(3)

Objective: To find out which maternal anthropometric parameter is the best indicator for birth outcome.

Study Design: Observational prospective study with correlation.

Subject: All booked cases of antenatal mothers in first trimester and their newborn babies delivered at the Hi-Tech Medical College and Hospital during November 2014 to October 2016 were taken as the study population.

Result: Occurrence of low birth weight (LBW) was higher(76.8%) in mothers having BMI <18. Only 7.7% LBW babies were seen in mothers having BMI 18-26. Occurrence of LBW was higher(58.1%) in mothers having MUAC (Mid upper Arm Circumference)<23cms. The occurrence of low birth weight was higher in mothers having weight <45kg and more than normal birth weight in mothers having weight ≥ 45kg. Out of 520 mothers 88(16.9%) had height <145cms and 432(83.1%) with height >145cms. LBW babies in mothers with height <145cms is 28.4% and in mothers with height >145cms is 27.3% (p=0.628). Mothers with height ≤ 145cms and BMI <18kg/m2 gave birth to 23 (92%) babies with birth weight < 2500gms and all were NVD and 2 (8%) babies with birth weight 2500gms to 3000 gms with NVD. Out of 63 babies of mothers with height ≤ 145cms and BMI >18kg/m2, 2 (3%) had birth weight <2500 gms, 42(66%) had birth weight 2500-3000, 19 (30%) with birth weight ≥ 3000. Mothers with height ≤ 145cms and BMI >18kg/m2 had 2 (3%) babies with birth weight < 2500 gms and all had normal vaginal delivery (NVD). 42(66%) babies with birth weight 2500 to 3000gms and 30 (71%) delivered by NVD and 12 (29%) by LSCS, 19 (30%) babies with birth weight ≥ 3000gms among which 6 (31.5%) delivered by NVD and 13 (68.4%) by LSCS.

Conclusion: Maternal weight, BMI and MUAC have strong positive association with birth weight of newborns. Interventions during pregnancy should be taken to improve nutritional status of the mother by which it is possible to improve the birth weight of newborn BMI having closest relationship with birth-weight which tends to be inversely proportional to height and directly proportional to weight. Out of the four parameters examined height didn't seems to have any relation with weight.BMI of the mother is the best indicator of the weight of the newborn. As per the reports short height speaks of the obstetrics outcome. Therefore high BMI and low height can be predictive of a cephalopelvic disproportion, which

has a direct bearing in the mode of delivery.To save the newborn from distress and reduce neonatal mortality and improve quality of life which could have been the result of hypoxic ischemic encephalopathy, early assisted delivery can be planned in vulnerable segment.

Keywords: Anthropometry, birthweight,BMI, MUAC, Height, Weight, LSCS(Lower Segment Caeserian Section), LBW (Low Birth Weight).

Introduction

Maternal body frame is the first determinants of neonatal biometrics; predominantly their birth weight and length, which are closely related to perinatal morbidity and mortality (1). Itis also known that mother's nutritional status is a key indicator of infant's and its early growth features. Birth weight and length are clearly related to mother's nutritional(2) and anthropometric factors(3) respectively. The anthropometric measurements that are commonly used as indices of growth and development are height, weight and mid-arm circumference (4). The growth of neonates were reported to be influenced by some maternal variables such as age, parity, social class and ethnicity(5). It was reported that maternal anthropometry is a potentially valuable tool in the evaluation of pregnancy status and prediction of birth weight(6). Several maternal factors such as age, body height, pre-gestational body weight, gestational weight gain, parity, gestational age, smoking during pregnancy, ethnicity, general health status, and dietary habits during pregnancy may influence the foetal growth which manifests in birth length and birth weight(7).

Undernourishment in the womb increases the risk of death in the early part of child's life. Those who survive tend to have impaired immune function and increased risk of disease.They are likely to remain undernourished, with reduced muscle strength, cognitive abilities and IQ throughout their lives. As adults, they suffer a higher incidence of diabetes and heart disease.(8)Low birth weight (LBW) is defined as a weight at birth of less than 2500 grams irrespective of the gestational age.(9) In 2013, nearly 22 million newborns, an estimated 16 per cent of all babies born globally, had low birth weight. Since, nearly half of the world's infants are not weighed at birth, accurate monitoring is challenging.(10)

Reduction by at least one-third in the incidence of low birth weight is one of the seven major goals of the "A WORLD FIT FOR CHILDREN" programme of the United Nations. (11) Monitoring improvement in low birth weight is thus being given high priority by the UN , as well as by national governments and the international communities.(12)

2014, South Asia had the highest incidence of low birth weight, with one in four newborns weighing less than 2,500 grams. 66% of the South Asian babies were not weighed at birth. Although data on low birth weight are adjusted to account for underreporting, they are still likely to underestimate the true magnitude of the problem in the region.(13)

"According to the UNICEF global databases October 2014, India bore the fourth highest burden of low birth weight babies of 28%, after Mauritania (35%), Pakistan (32%) and Yemen (32%).(14)

Low birth weight babies include both preterm and term small for date babies. Their clinical problems and prognoses are quite different from each other. High incidence of LBW babies in our country is accounted for by a higher number of babies with intra uterine growth retardation (small-for-date) rather than the preterms.(15)

96 per cent of low birth weight occurs in the developing world, reflecting the higher likelihood of these babies being born in poor socio-economic conditions, where womenare more susceptible to poor diet and infection and more likely to undertake physically demanding work during pregnancy(16). It reflects, further, a generational cycle of under-nutrition, the consequences of which are passed along to children by mothers who are themselves in poor health or undernourished.(17)

Over 80% of all neonatal deaths, in both developing and developed countries, occur among the LBW babies. Low birth weight is also a major negative determinant of success and duration of breast feeding, which is a well known protective asset against infant deaths in the developing world. It is estimated that in a developing country, LBW infants have 2.3 times increased risk of mortality due to infections compared to normal birth weight babies after controlling for all the confounding variables. The neurodevelopmental sequelae of birth asphyxia are found to be three times more common in LBW babies compared to their normal weight counterparts. Small-for-date babies remain stunted throughout life leading to impaired work capacity.(18)

Previous studies reported causes of LBW which include hard manual labour, maternal nutrition, economic condition, maternal height, maternal weight and most importantly, mother's age and parity19,20,21,22,23,24,25. The usefulness of MUAC for screening women at risk of poor pregnancy outcome is promising both on theoretical grounds (It reflects maternal fat and /or lean tissue stores).Relationship between MUAC and weight26'29 is independent of gestational age(27,28).Maternal anthropometric measurements provide a simple, cheap and available means of predicting birth weight with a variable degree of reliability.

Birth weight is the most sensitive and reliable indicator of the health in a community. It is universally acknowledged that size at birth is an important indicator of foetal and neonatal health in the context of both individual and community. Birth weight in particular is strongly associated with neonatal and post-neonatal mortality and with infant and child morbidity(30). Hence the study was planned to have a re-look at it.

Material& Methods

Type Of Study: Observational prospective study.

Study design: All booked cases of antenatal mothers in first trimester and their newborn babies delivered at the Hi-Tech Medical College and Hospital during one year period were studied. Pregnant women whose expected delivery date was up to August 2016 and accorded informed consent were included.

Inclusion criteria: All women who received prenatal care and delivered in Hi-Tech medical college and hospital were included in the study.

Exclusion criteria:

- Babies with any obvious congenital anomalies.
- Babies who had any birth injuries like limb fractures / cephalohaematoma /brachial palsy etc.
- Babies who were very sick and required oxygen therapy.
- Maternal infection leading to preterm delivery.
- Mothers who were smokers, consumers of alcoholic beverages.
- Mothers on medication for chronic medical problems.
- Maternal use of Injection/ oral steroid for prolonged period(>2weeks).
- Twin pregnancy.

Results:

Table 1:-Frequency Distribution According To Birth Weight

Birth weight in (GM)	Frequency	Percent
<2500	143	27.5
2500 to 3000	277	53.3%
? 3000	100	19.2%
Total	520	100%

Out of 520 newborns studied, 377(72.5%) were of normal birth weight and 143(27.5%) were low birth weight (LBW), weighing <2500gms.

Anthropometric Characteristic of 520 expectant mothers: Their Anthropometric Measurement sincluded height, weight, BMI, MUAC as shown in the table below (Table 2).

Table -2: - Descriptive Statistics of Mother's Anthropometric Measurements

Descriptive Statistics				
	Minimum	Maximum	Mean	Std. Deviation
Height	135.00	165.00	148.7019	4.86678
Weight	32.00	63.50	43.3717	5.84406
BMI	14.15	26.16	19.6273	2.54598
MUAC	21.00	32.00	25.2487	2.61037

Table -3:- Association Between Birth Weight And Mother's BMI, Mother's MUAC, Mother's Weight, Mother's Height

BMI	Birth weight			Total	P value	Significance
	<2500	2500-3000	≥3000			
<18	129(76.8%)	32(19.0%)	7(4.2%)	168(32.30%)		
18-21	11(5.9%)	152(81.7%)	23(12.4%)	186(35.76%)	<0.001	Significant
21-26	3(1.8%)	93(56.0%)	70(42.2%)	166(31.92%)		
MUAC	Birth weight			Total	P value	Significance
	<2500	2500-3000	≥3000			
<23	61(58.1%)	38(36.2%)	6(5.7%)	105(20.19%)	<0.001	Significant
23 - 29	82(20.2%)	234(57.6%)	90(22.2%)	406(78.07%)		
>29	0(0.0%)	5(55.6%)	4(44.4%)	9(1.73)		

Mother's Weight in Kgs	Birth Weight Groups			Total	P value	
	<2500	2500-3000	≥3000			
<45	134(44.1%)	140(46.1%)	30(9.9%)	304(58.46%)	< 0.001	Significant
≥45	9(4.2%)	137(63.4%)	70(32.4%)	216(41.53%)		
Mother's Height (cms)	Birth weight			Total	P value	Significance
	<2500	2500-3000	≥3000			
≤145	25(28.4%)	41(46.6%)	22(25.0%)	88(16.92%)	0.628	Not significant
>145	118(27.3%)	236(54.6%)	78(18.1%)	432(83.07%)		

The occurrence of low birth weight was higher 129(76.8%) in mothers having BMI <18 and normal weight baby in mothers having BMI 18-26. This association is found to be statistically significant.

The occurrence of low birth weight was higher in mothers having MUAC <23cms and normal or more than normal weight babies in mothers having MUAC >23cms. This association is found to be statistically significant.

The occurrence of low birth weight was higher 134(44.1%) in mothers having weight <45kg and lower 9(4.2%) in mothers having weight ? 45kg. This association is found to be statistically significant.

Out of 520 mothers 88(16.9%) had height ? 145cms and 432(83.1%) with height >145cms. LBW babies in mothers with height ?145cms is 25 (28.4%) and in mothers with height >145cms is 118(27.3%), (p=0.628). No correlation found between maternal height and birth weight.. There was no significant correlation between mother's height and the occurrence of low birth weight

Table 4 :- Birth Out come and mode of delivery in mothers with height ≤ 145cms and BMI <18kg/m2

Birth weight group	Frequency (%)	Mode of delivery	
		NVD	LSCS
<2500	23 (92%)	23 (100%)	0 (0%)
2500-3000	2(8%)	2 (100%)	0 (0%)
? 3000	0 (0%)	0 (0%)	0 (0%)
Total	25 (100%)	25 (100%)	0 (0%)

Mothers with height ≤ 145cms and BMI <18kg/m2 gave birth to 23 (92%) babies with birth weight< 2500gms and all had NVD.Only 2 (8%) babies with birth weight 2500gms to 3000 gms had NVD.

Table 5 :- Birth out come & mode of delivery in mothers with height ≤145cms and BMI >18kg/m2

Birth weight group	Frequency (%)	Mode of delivery	
		NVD	LSCS
<2500	2 (3%)	2 (100%)	0 (0%)
2500-3000	42(66%)	30 (71%)	12 (29%)
? 3000	19 (30%)	6 (31.5%)	13 (68.4%)
Total	63 (100%)	38 (60%)	25 (40%)

Mothers with height ≤ 145cms and BMI >18kg/m2 had 2 (3%) babies with birth weight < 2500 gms and had NVD. On the other hand, 42(66%) babies had birth weight 2500 to 3000gms and 30 (71%) were delivered by NVD, 12 (29%) by LSCS. 19 (30%) babies had birth weight ≥ 3000gms and 6 (31.5%) among them had NVD and 13 (68.4%) had LSCS.

Table 6:- Correlation Between Mother's Anthropometric Measurements and Birth Weight.

Correlation		Birth weight
BMI	Pearson correlation	0.692
	P value	<0.001
MUAC	Pearson correlation	0.607
	P value	<0.001
Mother's weight	Pearson correlation	0.660
	P value	<0.001
Mother's height	Pearson correlation	0.021
	P value	0.628

A statistically significant high correlation was found between mother's BMI, MUAC, Weight and Birth weight of newborn. No significant correlation is found between mother's height and birth weight of newborn.

Non-parametric receiver operative characteristic (ROC) curve analysis was done, and ROC curves were used to evaluate the accuracy of various anthropometric measurements, indicated by the area under the curve (AUC).

ROC Curve

BMI ●● , MUAC ★★ ,

Weight ▼▼ , Height ✦✦,

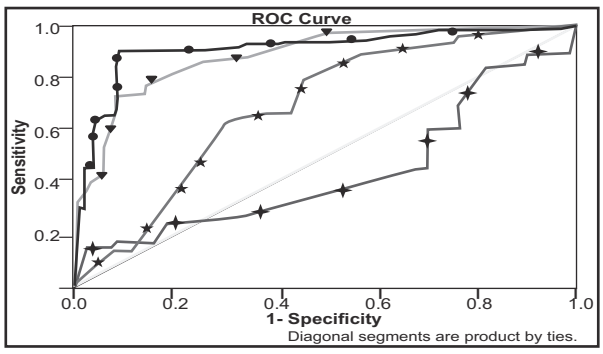

Table-10 :- Area under the curve (AUC) Area Under the Curve

Test Result Variable(s)	Area	Std. Errora	Asymptotic Sig.b	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
BMI	.906	.015	.000	.877	.935
MUAC	.683	.028	.000	.628	.738
Weight	.882	.016	.000	.850	.914
Height	.437	.027	.026	.384	.490

The AUC was found to be maximum with BMI followed by weight and MUAC, clearly depicts their relative accuracies as a marker of low birth weight

Table 11. Cut off Value For Anthropometry Of Mothers For Birth Weight <2500gms

Birth weight (gms)	BMI (Kg/m2)	MUAC (cms)	WEIGHT (Kg)
< 2500	18.04	22.75	42.50

Discussion :

It was observed thatoccurrence of low birth weight was higher(76.8%) in mothers having BMI <18 and only 7.7% LBW babies were seen in mothers having BMI 18-26 . This association was found to be statistically significant. The finding is similar with Kramer (31) who found that mothers who were underweight with BMI <18 kg/m2 had significantly higher incidence of having low birth weight babies and concluded that maternal nutritional factors both before and during pregnancy account for >50% of cases of LBW in developing countries. Han Z et al(32) found that pregnant women with BMI ?23 kg/m2 (<20 kg/m2 in most studies) had increased risk of having LBW infant (RR 1.52, 95%CI: 1.25-1.85) in developing countries.

Occurrence of LBW was higher (58.1%) in mothers having MUAC <23cms and more than normal weight baby in mothers having MUAC >23cms. This association was found to be statistically significant. Shrivastava,J. et al (33) in their study found that 81% mothers of LBW babies had MUAC < 23 cm while only19% had MUAC of more than 23cms. The mean MUAC in their study and control group was 20±1.12 and 25.5±1.31 cms, respectively (p<0.0001).

Birthh LBWbabies was higher in mothers having weight <45kg. Normal (>2500 Grams) baby were born to mothers having weight ? 45kg.This association is found to be statistically significant. This is in agreement with study of Fairley et al.(34)Shamsum et al(35) documented that maternal anthropometric parameters such as weight, height, body mass index (BMI), weight gain during pregnancy, nutritional status and socioeconomic status, are some well-established determinants of birth weight of the neonate.Nahar S, et al(36)conducted astudy to determine whether maternal anthropometry can predict birth weight, and if so, to identify which cut-off values provided the best prediction of low birth weightin a field situations. In this Community-based longitudinal study, a total of 1104 normotensive, non-smoking pregnant women who attended community nutrition centers were studied from first presentation at the center until delivery of their child. The frequency of LBW(<2500g) was 17%. Polynomial regression analysis showed that the

best predictors of birth weight (Based on adjusted R2 values) were in general, weight at registration with adjusted R2 ranging from 2.5% to nearly20%.Weight at registration continued to be the best predictors of LBW. Sensitivity and specificity curves were drawn for each registration month, body mass index and different weight gain groups, using different weight and height combinations. The results showed that for registration month 3-5, a combination of weight (<45 kg) and height (<150cm) gave the highest sensitivity (50%).

Out of 520 mothers 88(16.9%) had height <145cms and 432(83.1%) with height >145cms. LBW babies in mothers with height <145cms is 28.4% and in mothers with height >145cms is 27.3% (p=0.628). No correlation found between maternal height and birth weight.Mothers with height ? 145cms and BMI <18kg/m2 gave birth to 23 (92%) babies with birth weight < 2500gms and all were NVD, 2 (8%) babies with birth weight 2500gms to 3000 gms were delivered normally. Out of 63 babies of mothers with height ? 145cms and BMI >18kg/m22(3%) had birth weight <2500 gms, 42(66%) had birth weight 2500-3000, and 19 (30%) with birth weight ? 3000. Mothers with height ? 145cms and BMI >18kg/m2 had 2(3%) babies with birth weight <2500 gms and all were delivered by NVD, 42(66%) babies with birth weight 2500 to 3000gms and 30 (71%) delivered by NVD and 12 (29%) by LSCS. 19 (30%) babies with birth weight ? 3000gms. 6 (31.5%) of them were delivered by NVD and 13 (68.4%) by LSCS.

Conclusion

Based on the results of this study and other studies reported in this literature, it can be concluded that anthropometry, BMI, weight and MUAC have strong positive association with birth weight of newborns.

Use of anthropometry to assess maternal malnutrition can be useful in reducing incidence of LBW.

Therefore, interventions during pregnancy should be taken to improve nutritional status of the mother.

BMI of mother showed closest relationship with baby's birthweight. It is inversely proportional to height and directly proportional to weight of mother. Out of the four parameters examined, height of mother didn't have any relation with weight of the newborn. But it had a direct relationship with the Pevic outlet diameter.

Though an inverse relationship could not be established, yet unit height without body mass did not reflect in fetal growth in utero.

High BMI and low height can be predictive of a cephalopelvic disproportion, which has a direct bearing in the mode of delivery.

To save the newborn from birth asphyxia, other stress and to reduce neonatal mortality aas well as to improve quality of life, ahigh risk group within the expectant mothers can be identified with height and BMI. They can be followed of in the field setting intensively and providedadequate facilities, early referral and timely intervention.

Declarations

Contributions: P : Conducted the study and drafted the manuscript; **SG:** Conceptualized and designed the study, guided through the study and finalized the manuscript with important intellectual inputs; The final manuscript was approved by all authors.

Conflict of interest /Competing Interest - Nil, None declared

Ethical approval: The study was approved by the Institutional Ethics Committee.

Funding - Intramural funding from Hi-tech Medical College & Hospital Bhubaneswar, Odisha.

References

1. Guihard-Costa, A. M., Papiemik, E. and Kolb, S.(2004)."Maternal predictors of subcutaneous fat in the term newborn," Acta Paediatrica, International Journal of Paediatrics, 93(3), 346-349.
2. Muthayya, S. (2009)."Maternal nutrition & low birth weight-what is really important?" Indian Journal of Medical Research, 130(5), 600-608.
3. Witter, F. R. and Luke,B. (1991). "The effect of maternal height on birth weight and birth length," Early Human Development, 25(3), 181-186.
4. Harrison, D., Marker, H., Heese, H. D., Mann, M. D. and Berelowitz, J. (2001). Errors in anthropometric measurements in neonates and infants. Curationis, 24 (2), 23-27.
5. Wildschut, H. L J. (1999). Sociodemographic factors: Age, parity, social class and ethnicity. In: James DK. Steer PJ. Weiner CP. Gonik B. High risk pregnancy, 2nd Ed. W.B. Saunders Co, London; 39-52
6. Benjumea, M.V. (2007). Diagnostic accuracy of five gestational references to predict insufficient birth weight. Biomedica,27, 42-55
7. Dhall, K. and R. Bagga, (1995). Maternal determinants of birth weight of North Indian Babies. Indian Journal of Paediatric, 62, 333-344.
8. Barker DJP (2004)The Developmental Origin of Adult Diseases and Heart Diseases.Journal of the American College of Nutrition.23 (6) , 588S-595S.
9. World HetmlfOrganisation. International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Geneva : WHO ;1992
10. United Nations Children's Fund Data: Monitoring The Situation of Children and Women: Nutrition" Low Birth Weight Updated May 2015 (www.data.unicef.org /nutrition/low-birth-weight)
11. United Nations -General Assembly- Twenty Seventh Special Session Agenda Item 8 And 9-Resolution Adopted By General Assembly.Distr: General. 11 Oct. 2002. : A/Res/ S -72/2-Pg. 9
12. Blanc A.K & Wardlaw T: Monitoring Low Birth Weight: An Evaluation of International Estimates and An Updated Estimation Procedure. Bulletin of The World Health Organization., March 2005,83 (3),178-85
13. United Nations Children's Fund Global Databases, 2014, Based On Multiple Indicator Cluster Surveys (MICS), Demographic and Health Surveys (DHS) and Other Representative Surveys, 2009-2015 (For % Not Weighted In 2008-2012) With Exception Of India And Indonesia.
14. United Nations Children's Fund Statistics-UNICEF Global Databases, 2014. Monitoring The Situation of Children and Women: Low Birth Weight: % of Infants Weighing <2500gm At Birth::Last Update October,2014 (data.unicef.org)
15. Singh M. Care of the Newborn. 7thed. New Delhi, Sagar Publication April 2010 p.234
16. United Nations Children's Fund:Low Birth Weight:Country, Regional and Global Estimates. New York And Geneva,2004, pp 2-3
17. United Nations Children's Fund: Progress For Children : A Report Card On Nutrition; No.4, May 2006 (www.unicef.org/progress for children/2006n4/index_LBW.html)
18. Singh M. Care of the Newborn. 8th Ed. New Delhi, Sagar Publications April 2014.p-8, p.244
19. Cramer, J.C., (1995). Racial and ethnic difference in birth weight: The role of income and financial assistance. Demography, 32,

231-247.

20. Mavalankar, D.V., Trivedi, C.C. and Gray, R.H. (1994). Maternal weight, height and risk of poor pregnancy outcome in Ahmedabad, India. Indian paediatric .31, 1205-1212.

21. Kamaladoss, T., Abel, R. and Sampath-Kuman, V. (1992). Epidemiological co-relates of low birth weight in rural Tamil Nadu. Indian Journal of Paediatrics, 59:Pp. 299-304.

22. Makhija, K. and Murthy, G.V.S. (1990). Socio-biologic factors influencing low birth weight at rural project hospital. Journal of Indian Medical Association, 88(3), 215-217

23. Pakrasi, K., Sil, S., Dasgupta, P. and Dasgupta, I. (1985). Pattern of low birth weight in the Bengali newborns. Indian Journal of Physiology and Human Genetic, 11(2), 107-122

24. Fedrick, J. And Adelstein, P. (1978). Factor associated with low birth weight of infants delivered at rest. British Journal of Obstetrics and Gynaecology, 85, 1-7.

25. Ghosh, S., Hooja, V., Mittal, S.K. and Verma, R.K. (1977). Biosocial determinants of birth weight. Indian journal of Paediatrics, 14, 107-114.

26. Krasovec, K . An investigation into the use of maternal arm circumference for nutritional monitoring of pregnant women. Baltimore, 1889.p119-31.

27. Shah, A . Appropriate technology and perinatal care: the Kasa experience.Adv. Int. Matern. Child Health.1982,2:1-15.

28. Leching, A. Predicting risk of developing risk of delivering low birth weight babies : which indicator is better? J.Trop, Pediatr :1988, 34,34-41.

29. Ricalde, A.E. Mid-upper Arm Circumference in pregnant women and its relation to birth weight.1998,4:p488-94.

30. WHO. (1995). Physical Status: the use and interpretation of anthropometry. Report of a WHO expert committee. WHO Technical Report Series,854, 121-160.

31. Lawoyin, T.O. (2007). Infant and maternal deaths in rural south west Nigeria: a prospective study. African Journal Medical Sciences, 36, 235-241.

32. Han Z, Mulla S, Beyene J, Liao G, McDonald SD (2011) Maternal underweight and the risk of preterm birth and low birth weight: a systematic review and meta-analyses. Int J Epidemiol 40: 65-101

33. Shrivastava,J. , Agrawal,A., Giri, A.Maternal anthropometry in relation to birth weight of newborn: A prospective hospital based study. Indian J Child Health.2016;3(1):59-63.

34. Fairley, L. (2000). Changing patterns of inequality in birth weight and its determinants: A population-based study, Scotland. Paediatric Perinatology and Epidemiology, 19: 342-51

35. Shamsun,N. , Mascie-Taylor, C.G. and Begum, H.A. (2007). Maternal anthropometry as a predictor of birth weight. Public Health Nutrition; 10, 965-970.

36. Nahar S, Mascie, Taylor CG, Begum HA. Maternal anthropometry as a predictor of birth weight. Public Health Nutr. 2007 Sep;10(9):965-70.